

KAPL AIR CLEANING PROGRAM

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ABSTRACT

A brief description of the air cleaning requirements at the Knolls Atomic Power Laboratory is given. A total of 407,600 cfm of air is cleaned in which the CWS-6 filter units are used to clean approximately 80 per cent of the air at the laboratory. Caustic scrubbers and an electrostatic precipitator are utilized in specific air cleaning operations.

The efficiency of the air cleaning units is indicated by the low concentrations of radioactive and toxic materials in the environs which are tabulated.

The collection efficiencies of six filter media used for air cleaning and air sampling are tabulated as a function of face velocity and particle size.

INTRODUCTION

Before discussing the air cleaning requirements and investigations at the Knolls Atomic Power Laboratory, it seems appropriate that one should describe the Laboratory and its program. The Knolls Atomic Power Laboratory is operated by the General Electric Company under contract with the United States Atomic Energy Commission. Mr. Karl R. Van Tassel is the General Manager. Dr. Kenneth H. Kingdon is the Technical Department Manager while Mr. F. E. Crever, Jr., is the Engineering and Projects Department Manager.

The Knolls Atomic Power Laboratory is primarily concerned with the development, design, manufacture, and installation of an intermediate reactor for submarine propulsion. This reactor, first of its type, uses uranium as fuel and sodium as a coolant and will be installed in an actual portion of a submarine under construction at our West Milton Site. The reactor and engine room compartment of this submarine prototype will be enclosed in a tank of water located within a gas-tight 225 foot steel sphere, the largest ever built. The Laboratory is also engaged in developing a submarine intermediate reactor for actual installation in a sea-going vessel. In addition to this type of work, KAPL is responsible for furnishing the necessary development work as assistance to the Hanford and Savannah River operations offices. This effort is directed toward improving production facilities.

The work on these projects, illustrated in Figure 1, is carried on in the following facilities: the Knolls Atomic Power Laboratory, located in the Town of Niskayuna; Peek Street Site, located in the city of Schenectady; the Alplaus Site, located in the Town of Alplaus, and the West Milton Site, located in the Town of West Milton. The Knolls Atomic Power Laboratory (KAPL) is located on a plot of approximately 170 acres of land in the Town of Niskayuna, New York, about 5 miles east of the center of the City of Schenectady and about 1/2 mile from the General Electric Company Research Laboratory. It was completed January 1, 1950, at a cost of approximately \$28,000,000.

TABLE 1

<u>Buildings</u>	<u>No. Exhaust Units</u>	<u>Capacity Cleaning System, in cfm</u>	<u>Air Cleaning System</u>	<u>Description of Areas Ventilated</u>	<u>Units Served or Zones Covered</u>
Chemistry and Chemical Engineering (E-1, G-1)	5(E-1, 2, 6, 7, 8)	154,000	Glass Wool and CWS	Laboratories, hoods hot caves, basements	197
Liquid Waste Processing (E)	2(475-3, 475-4)	43,000	Glass Wool and CWS	Cells, evaporator areas, hot drain tunnels, control and change rooms	62
Separations Pilot Plant (G-2)	2(E-4, 475-1, 475-2)	103,500	Glass Wool and CWS	Weigh tank and constant head areas, offices, hot cave, crane gallery, cell access corridors, sampling and rotameter aisles, cells	94
Separations Pilot Plant (G-2)	1	200	NaOH Spray Column - 13'	Dissolver off-gas and head end process vessels vent air scrubber	---
Separations Pilot Plant (G-2)	1	1,400	NaOH 30" I.D. x 47' high porcelain-ring packed, column 23' high	Hold-up and feed, recycle tanks, banks, and decontamination room	---
Manufacturing (D-3, 4)	1(E-1)	78,600	Multiclone precipitator, electrostatic precipitator, glass wool	Machine shop ventilation, metal working laboratory, laboratory hoods, vault, change areas, (high and low velocity systems)	122
Manufacturing (D-1, D-4, Q-4)	7(E-4, 12, 13) (E-3, A, E, B)	21,600	Glass Wool and CWS	Health Physics Laboratory, laboratories and hoods, furnaces and filling room, vault, degreaser	38
Physics and Metallurgy (F, Z-3, A-2)	4(B-3, 4)	4,500	Glass Wool and CWS	Hoods	4
Radioactive Materials Laboratory (E-2)	3	6,800	Glass Wool and CWS	Cave Area, decontamination area, hot boxes	12
Total	26	407,600	---	---	529

The Atomic Power Laboratory, as shown in the composite photographs, consists of a main group of five interconnected buildings providing space for administration, cafeteria, physics laboratory, general shops, and metallurgical and engineering laboratories. In addition, there is another group of three interconnected buildings housing a chemical laboratory, pilot plant laboratory, and Separations Process Research Unit. There are also 12 detached buildings providing for service facilities. There is approximately 371,000 square feet of gross floor space in these facilities. Additional site facilities include a Preliminary Pile Assembly which is a flexible mockup for the intermediate nuclear reactor, a Thermal Test Reactor, used primarily for research purposes, and Test Cells for a Radioactive Materials Laboratory.

Approximately 20 per cent of the staff is employed at the Peck Street Site located in Schenectady about one mile north of the center of the city, and the liquid metal research work is conducted at the Alplaus Site which is situated in the Town of Alplaus, approximately 3 miles northeast of Schenectady.

The West Milton Site is located on a plot of about 4,000 acres in the County of Saratoga, approximately 18 miles north of Schenectady. The construction of the 225 foot sphere to house the submarine prototype, shown in the composite photograph, has been completed and the sphere has been successfully pressure tested. Six permanent-type buildings will be erected at this site. There are approximately 2,000 people employed at the Knolls Atomic Power Laboratory and its facilities.

AIR CLEANING REQUIREMENTS AT KAPL

To describe the KAPL air cleaning program, the air cleaning requirements will be enumerated by a consideration of the numbers and types of air cleaning systems used together with the capacities of these systems and the areas serviced. The efficiencies of these air cleaning systems will be indicated by the concentrations of toxic elements in the stack air effluents and environs.

However, before illustrating the data on the KAPL air cleaning systems and the concentrations of toxic materials in the stack effluent and the environs, a few pictures of the stack air cleaning systems, typical areas ventilated and the environmental monitoring equipment will be presented to aid in the description of the KAPL air cleaning program.

A 100-foot stainless steel stack serving the Separations Pilot Plant is shown in Photograph 1120906. The Liquid Waste Processing building which is situated to the left of the main building in the photograph has a 50-foot high stainless steel stack. To the right of the 100-foot stack is a caustic vent scrubber serving in series with a glass wool CWS filter unit. Separations Process gases and entrained particulate material are vented through this scrubber and CWS filter. On top of the Pilot Plant Building you can see one of many typical stubby air exhaust pipes utilized at KAPL. These exhaust pipes are approximately 16 to 20 feet above roof levels.

A typical filter unit enclosing glass wool and CWS filters is shown in Photograph 1120929. A portion of the cyclone separator which precedes the electrostatic precipitator in the Special Materials Machine Shop where beryllium and uranium are machined is depicted in Photograph 1086995. A hood in which highly radioactive materials are manipulated is illustrated in Photograph 1120898. Photograph 1086992 shows ventilation provided in the Special Materials Machine Shop. Photograph 1120928 depicts a cave area in which highly radioactive materials are studied for radiation damage or effect on reactor structural material or fuel elements. A typical air monitoring instrumentation employed at KAPL is shown in

Photograph 1096993. A GM counter and an air ionization chamber are used for the monitoring of air in the environs.

Photograph 1107115 depicts an environmental continuous air particulate monitoring unit employing a GM counter, a vibrating reed electromotor and continuous recorder, scalars and recorders for the two GM counters.

An I-131 scrubber used for stack and environmental air monitoring purposes is illustrated in Photograph 1104414. Not shown, however, is a Kanne Chamber unit used to detect the radioactive noble gases and tritium.

The data in Table 1 indicate the various buildings on the Knolls Site, the number of air exhaust units, the total capacity of the air cleaning units, the type of air cleaning systems, a general description of areas ventilated, and a number of units served or zones covered. You can readily see that the glass wool CWS filter systems predominate, that the cyclone separator-electrostatic precipitron is a major system while the caustic scrubbers are confined to serving the venting of process vessels in the Pilot Plant and treat a very small volume of the laboratory air at KAPL.

The nature and amounts of toxic elements emitted in 1952 from the various laboratory buildings are listed in Table 2. Emission of radiogases is associated with short periods (a few hours) and dilution in large volume of stack air. These gases have presented no significant health hazard problems at KAPL. All these toxic elements are released into stacks discharging from 40,000 cubic feet of air per minute or more. The Separations Pilot Plant stack effluent is the most important factor in the contamination of atmosphere with fission products and alpha activity. The stack effluent from the Special Materials Machine Shop building (D-3) is the major potential source of beryllium contamination in the environment.

The data in Table 3 indicate to some degree the radiation levels at contact associated with the particulate filters. As one would expect process cell air filters are the highest.

The range of concentrations of the various toxic elements in the KAPL stack air effluents are illustrated by the data in Table 4. The data indicate that atmospheric air dilution must be relied upon for the Separations Pilot Plant stack exhaust air but the dilution factors required are low even at the maximum concentrations.

The data in Table 5 indicate that atmospheric dilution is also required to reduce I-131 concentration emitted from the Separations Pilot Plant, and the beryllium concentration released from the Special Materials Machine Shop building to permissible concentrations in the environs. The data indicate that the CWS filters are very effective in removing beryllium from laboratory hood exhaust air.

The data listed in Table 6 show that no concentration of beryllium above the prescribed limit of $0.01 \mu\text{g}/\text{M}^3$ was detected in the environs. The radioactive particle count represents sampling of three on-site and two off-site locations and is diluted by data from the West Milton Site. These data also reflect outside influences as well; however, maximum particle counts from KAPL operations exceed those associated with outside influence. The local particle problem results from the entrainment of particulate material from the separations process operations rather than from stack corrosion.

The filterable particulate fission product concentrations which were determined at the environmental stations at KAPL and West Milton are illustrated in Table 7. These concentrations represent 3- or 4-day averages. Building M-2 is in the prevailing wind direction from the stack at a distance approximately 10 stack heights away. The West Milton data are considered background data for

TABLE 2
AMOUNTS OF TOXIC ELEMENTS DISCHARGED INTO ATMOSPHERE - 1952

Building Stack	Beryllium Milligrams	Non-Volatile		I-131 Millicuries	Radioactive Gases Curies	Alpha Activity Curies
		Fission Products Curies				
D-3	110	--	---	---	---	---
D-4	11	--	---	---	---	---
E-1	---	--	---	---	~500	---
E-2	---	--	---	---	---	---
S.P.P.	---	40	113	113	91	0.7
Total	121	40	113	113	591	0.7

TABLE 3
ACTIVITY LEVELS OF AIR CLEANING SYSTEMS

<u>Building</u>	<u>Area</u>	<u>Radiation Levels</u> (Contact Measurement)	
		<u>mrep/hr</u>	<u>mr/hr</u>
E-1	Laboratory Hood Filter	500	50
E-2	Radioactive Materials Laboratory	10	5
G-1	Laboratory Hood Filter	175	10
G-2	Hood Filter	370	14
	Cell 1 Filter	20,000	1,500 at 3 ft.
H	Pipe Tunnel Filter	950	150

TABLE 4
STACK EFFLUENT CONCENTRATIONS AFTER AIR CLEANING

ALPHA ACTIVITY				
<u>Building</u>	<u>No. Samples</u>	<u>No. < 3 x 10⁻¹³ μc/cc</u>	<u>No. > 3 x 10⁻¹³ μc/cc</u>	<u>Maximum μc/cc</u>
G-2 (S.P.P.)	572	384	188	5.7 x 10 ⁻¹¹
G-2 (Laboratory 151)	248	248	---	---
E	521	521	---	---
E-2	73	66	7	1.8 x 10 ⁻¹²
E-1	502	502	---	---
G-1	246	246	---	---
FISSION PRODUCT ACTIVITY				
<u>Building</u>	<u>No. Samples</u>	<u>No. < 10⁻¹¹ μc/cc</u>	<u>No. > 10⁻¹¹ μc/cc</u>	<u>Maximum μc/cc</u>
G-2 (S.P.P.)	572	43	529	6 x 10 ⁻⁷
G-2 (Laboratory 151)	247	247	---	---
E	504	495	9	1.4 x 10 ⁻¹¹
E-2	72	26	46	6.7 x 10 ⁻¹¹
E-1	502	502	---	---
G-1	246	246	---	---

TABLE 5
STACK EFFLUENT CONCENTRATION AFTER CLEANING

<u>Building</u>	<u>No. Samples</u>	<u>No. >10⁻¹¹ µc/cc</u>	<u>Maximum µc/cc</u>	I-131
G-2 (S.P.P.)	464	154	4.7 x 10 ⁻⁸	
URANIUM				
<u>Building</u>	<u>No. Samples</u>	<u>No. <10⁻⁶ µg/cc</u>	<u>No. > 10⁻⁶ < 5 x 10⁻⁵ µg/cc</u>	<u>Maximum µg/cc</u>
D-3 (Machine Shop and Laboratories)	700	486	214	8.1 x 10 ⁻⁶
URANIUM (ENRICHED)				
<u>Building</u>	<u>No. Samples</u>	<u>No. <10⁻¹² µc/cc</u>	<u>No. > 10⁻¹² < 3.3 x 10⁻¹¹ µc/cc</u>	<u>Maximum µc/cc</u>
D-4 (Laboratories)	656	655	1	4.1 x 10 ⁻¹²
BERYLLIUM				
<u>Building</u>	<u>No. Samples</u>	<u>No. <0.10 µg/M³</u>	<u>No. >0.1 <1.0 µg/M³</u>	<u>Maximum µg/M³</u>
D-3 (Machine Shop and Laboratories)	694	693	1	0.2
D-4 (Laboratories)	655	655	---	0.02

TABLE 6
KAPL ENVIRONMENTAL AIR MONITORING - 1952

<u>Beryllium</u>			
<u>Location</u>	<u>No. Samples</u>	<u>No. < 0.01 $\mu\text{g}/\text{M}^3$</u>	<u>Maximum $\mu\text{g}/\text{M}^3$</u>
On site, downwind	136	136	< .01
<u>Radioactive Particle Count</u>			
<u>Location</u>	<u>No. Samples</u>	<u>Daily Average Number of Particles/10^3M^3</u>	<u>Maximum Monthly Average Number of Particles/10^3M^3</u>
Three on site	519	287	954
Two off site			

TABLE 7

KAPL ENVIRONMENTAL AIR MONITORING - 1952

Fission Product Activity, in 10^{-13} uc/cc

Period	Locations			
	Building K	Building M-2	Building A-1	Research Laboratory West Milton
- Average	<3	3.1	<3	<3
- Maximum	<3	8.6	<3	<3
- Average	<3	5.7	<3	<3
- Maximum	<3	17.0	<3	<3
- Average	<3	6.5	<3	<3
- Maximum	<3	18.	<3	<3
- Average	<3	40.	7.1	5.8
- Maximum	<3	310.	45.	<3
- Average	<3	302.	13.	3.4
- Maximum	<3	2400.	76.	<3
- Average	7.2	41.	12.	5.2
- Maximum	16.	190.	34.	11.
- Average	<3.	6.8	4.7	38.
- Maximum	3.3	25.	15.	5.6
- Average	3.0	7.4	3.7	14.
- Maximum	6.3	15.	7.	3.2
- Average	<3	<3.	<3	8.3
- Maximum	7.2	15.	<3	<3
- Average	<3	<3.	<3	<3
- Maximum	<3	<3	<3	<3
- Average	<3	<3	3.7	5.4
- Maximum	<3	3.1	20.0	<3
- Average	<3	206.2	<3	9.0
- Maximum	14	1400.0	5.8	<3
				7.2

TABLE 8

KAPL ENVIRONMENTAL VEGETATION MONITORING (FISSION PRODUCTS) - 1952

Period	Site Location	No. Sampling Points	No. > 20 x 10 ⁻⁶ $\mu\text{C/g}$	Average in 10 ⁻⁶ $\mu\text{C/g}$	Maximum in 10 ⁻⁶ $\mu\text{C/g}$
January	Knolls	7	2	20.5	34
	Near Knolls	7	3	36.6	53
	West Milton	no samples			
February	Knolls	6	1	21	21
	Near Knolls	3	0	*	-
	West Milton	1	1	34	34
	Knolls	6	4	22	36
March	Near Knolls	3	2	20.5	25
	West Milton	no samples			
April	Knolls	7	7	27.8	95
	Near Knolls	8	7	31.4	86
	West Milton	2	2	29.5	59
May	Knolls	7	3	27.0	62
	Near Knolls	8	3	23.6	35
	West Milton	5	1	24	24
June	Knolls	7	7	57.1	176
	Near Knolls	9	8	95.2	287
	West Milton	5	4	66.0	209
July	Knolls	7	2	25.5	59
	Near Knolls	8	2	23.1	51
	West Milton	4	0	*	-
August	Knolls	7	0	*	22
	Near Knolls	9	0	*	20
	West Milton	5	0	*	-
September	Knolls	7	1	37	61
	Near Knolls	9	0	*	30
	West Milton	no samples			
October	Knolls	7	0	*	21.1
	Near Knolls	9	0	*	-
	West Milton	3	0	*	-
November	Knolls	7	4	28.7	84.2
	Near Knolls	9	8	25.9	128.0
	West Milton	3	2	41.3	89.0
December	Knolls	7	6	44.1	138.0
	Near Knolls	9	9	40.6	127.
	West Milton	3	3	47.4	71.4

* < 20 x 10⁻⁶ $\mu\text{C/g}$

TABLE 9

KAPL ENVIRONMENTAL VEGETATION MONITORING (I-131) - 1952

Period	Site Location	No. Sampling Points	No. >3 x 10 ⁻⁶ $\mu\text{c/g}$	Average x 10 ⁻⁶ $\mu\text{c/g}$	Maximum x 10 ⁻⁶ $\mu\text{c/g}$
January	Knolls	7	5	6.4	15
	Near Knolls	7	1	5.3	5.3
	West Milton	0			
February	Knolls	6	0	-	-
	Near Knolls	3	0	-	-
	West Milton	1	0	-	-
March	Knolls	6	0	-	-
	Near Knolls	3	0	-	-
	West Milton	0			
April	Knolls	7	0	-	-
	Near Knolls	8	0	-	-
	West Milton	0			
May	Knolls	7	0	-	-
	Near Knolls	8	1	-	4.4
	West Milton	4	0	-	-
June	Knolls	7	2	3.3	8.3
	Near Knolls	8	0	-	-
	West Milton	5	0	-	-
July	Knolls	7	0	-	3.7
	Near Knolls	8	0	-	6.1
	West Milton	3	0	-	3.8
August	Knolls	7	0	-	5.5
	Near Knolls	9	0	-	-
	West Milton	4	0	-	-
September	Knolls	7	0	-	-
	Near Knolls	9	0	-	-
	West Milton	3	0	-	-
October	Knolls	7	0	-	-
	Near Knolls	9	0	-	-
	West Milton	3	0	-	-
November	Knolls	7	0	-	-
	Near Knolls	9	0	-	-
	West Milton	2	0	-	-
December	Knolls	7	0	-	-
	Near Knolls	9	0	-	-
	West Milton	3	0	-	-

TABLE 10

EFFICIENCY OF FILTER MEDIA

Filter Media	Maximum Efficiency			Minimum Efficiency		
	Efficiency, Per Cent	Particle Size, Micron	Face Velocity, cm/sec.	Efficiency, Per Cent	Particle Size, Micron	Face Velocity, cm/sec.
W-40	99.7	2.1	100	59.3	.2	10
W-41	99.6	2.1	10	85.2	.2	2
H-70	99.9	2.1	5,50	97.0	.2	10
AEC-1	>99.9	2.1	50,80	92.9	.2	1
CC-6	>99.9	2.1	2	98.2	.2	0.5
AAA	>99.9	2.1	20,50,80	97.5	.2	40

TABLE 11

EFFICIENCY OF FILTER MEDIA

Filter Media	Per Cent Efficiency (at 50 cm/sec and for 0.2 micron particles)	Penetration	Relative Penetration
W-40	97.2	2.8	4.0
W-41	98.4	1.6	2.3
H-70	98.9	1.1	1.6
AEC-1	99.3	0.7	1.0
CC-6	99.2	0.8	1.1
AAA	98.8	1.2	1.7

estimating outside influences. These concentrations indicate no significant inhalation hazards at the Knolls Site. Alpha activity determinations were below statistically significant values.

The status of vegetation contamination on the Knolls Site, vicinity and West Milton is indicated in Table 8. Variations in natural potassium activity, and outside influences make it difficult to assess the sole influence of local operations. West Milton samples, however, are a guide to the influence of outside sources. Contamination of vegetation due to activity in precipitation (rain or snow) is probably the dominant effect rather than the deposition from fall-out.

An occasional evidence of I-131 contamination in the environs is indicated by the data in Table 9.

Summing up the air cleaning statistics at KAPL, the most significant amounts of alpha activity, fission product activity, and radioactive particles are emitted from the Separations Process stack (approximately 100 ft. high). The stack effluent from Building D-3 roof stack (approximately 16 feet high) contains the most significant concentrations of beryllium. Atmospheric dilution, though usually of a low order, must be relied upon occasionally, even after treatment, to reduce airborne contaminants to acceptable levels from the point of view of inhalation hazard and vegetation contamination. The Separations Pilot Plant stack air effluent has received the greatest attention with respect to isotopic identification of radioelements emitted, particle size, and proper sampling methods.

AIR SAMPLING AND AIR CLEANING INVESTIGATIONS

Air sampling and air cleaning investigations at the Knolls Atomic Power Laboratory during fiscal year 1953 were grouped into three categories: (1) efficiency studies of filter media, (2) efficiency studies of air sampling and air cleaning units, and (3) the evaluation of the KAPL separations process stack effluent. Some of the results of efficiency studies of filter media are briefly discussed here.

Filter Efficiency Studies

The efficiency of six air sampling filter media was determined in the particle size range of 0.2 to 2.1 microns under the light microscope using Millipore filters. The filter media, Whatman-40 and 41, Hollingsworth and Vose-70, AEC-1, Chemical Corp 6 (CWS-6), and AAA (1106-B) glass fiber paper were tested throughout the face velocity range of 0.5 to 100 cm/sec. Efficiency was expressed on a size count basis for solid particles of 2.7 gm/cm³ density. The maximum and minimum efficiencies for these filter media in the specified ranges are listed in Table 10.

The maximum efficiency for all filter media was greater than 99.5 per cent at various face velocities for 2.1 micron particles. The minimum efficiency for all filter media except the Whatman was greater than 92.8 per cent for particle sizes of 0.2 micron. It is indicated by the data in Table 11, however, that at operating face velocities of 50 cm/sec, the efficiencies of all filter media are greater than 97 per cent even for 0.2 micron particles.

These efficiency studies of the filter media are being extended to the sub-microscopic range by analyzing under the electron microscope the particles entering and passing through the test filter media.

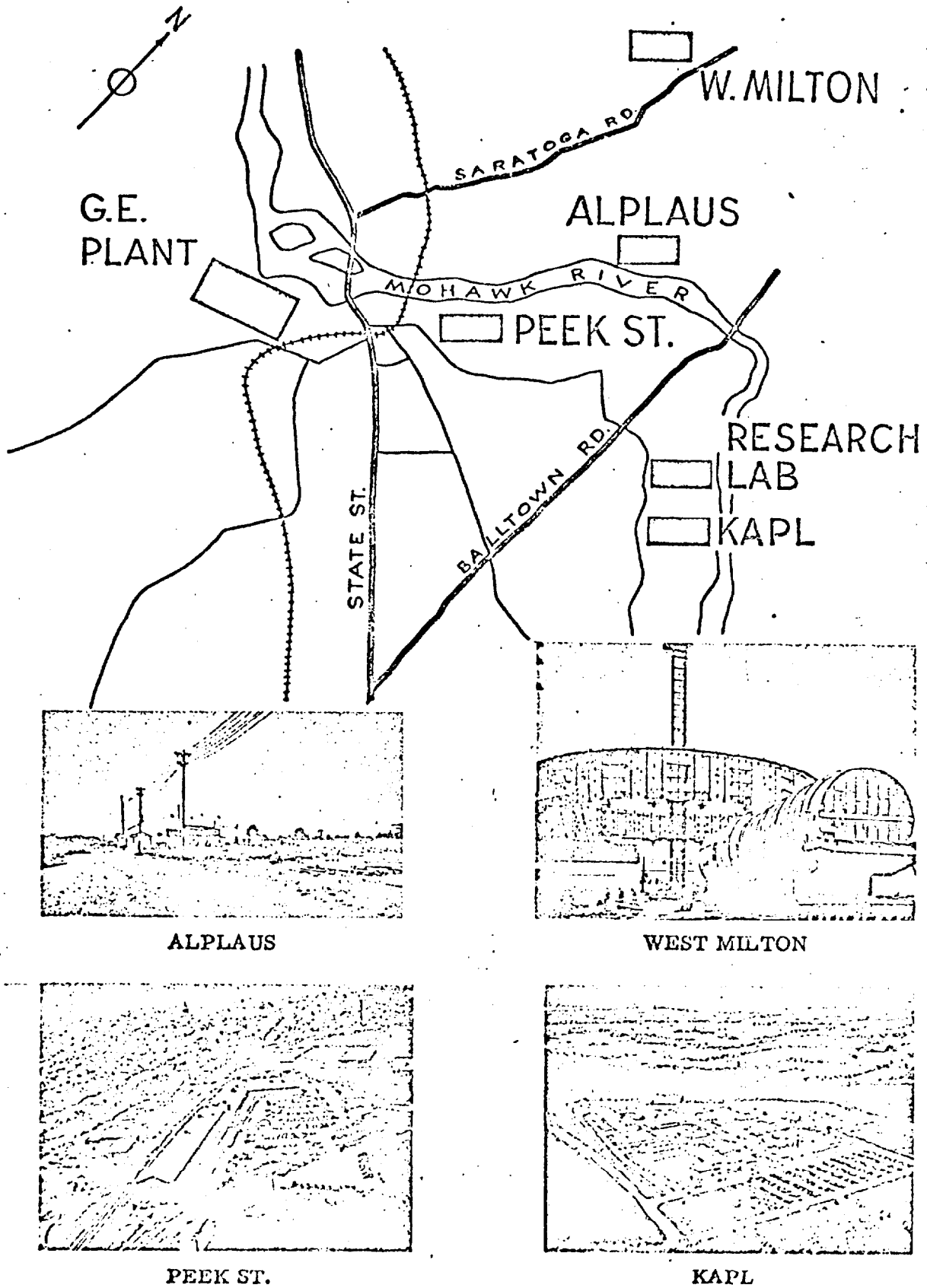
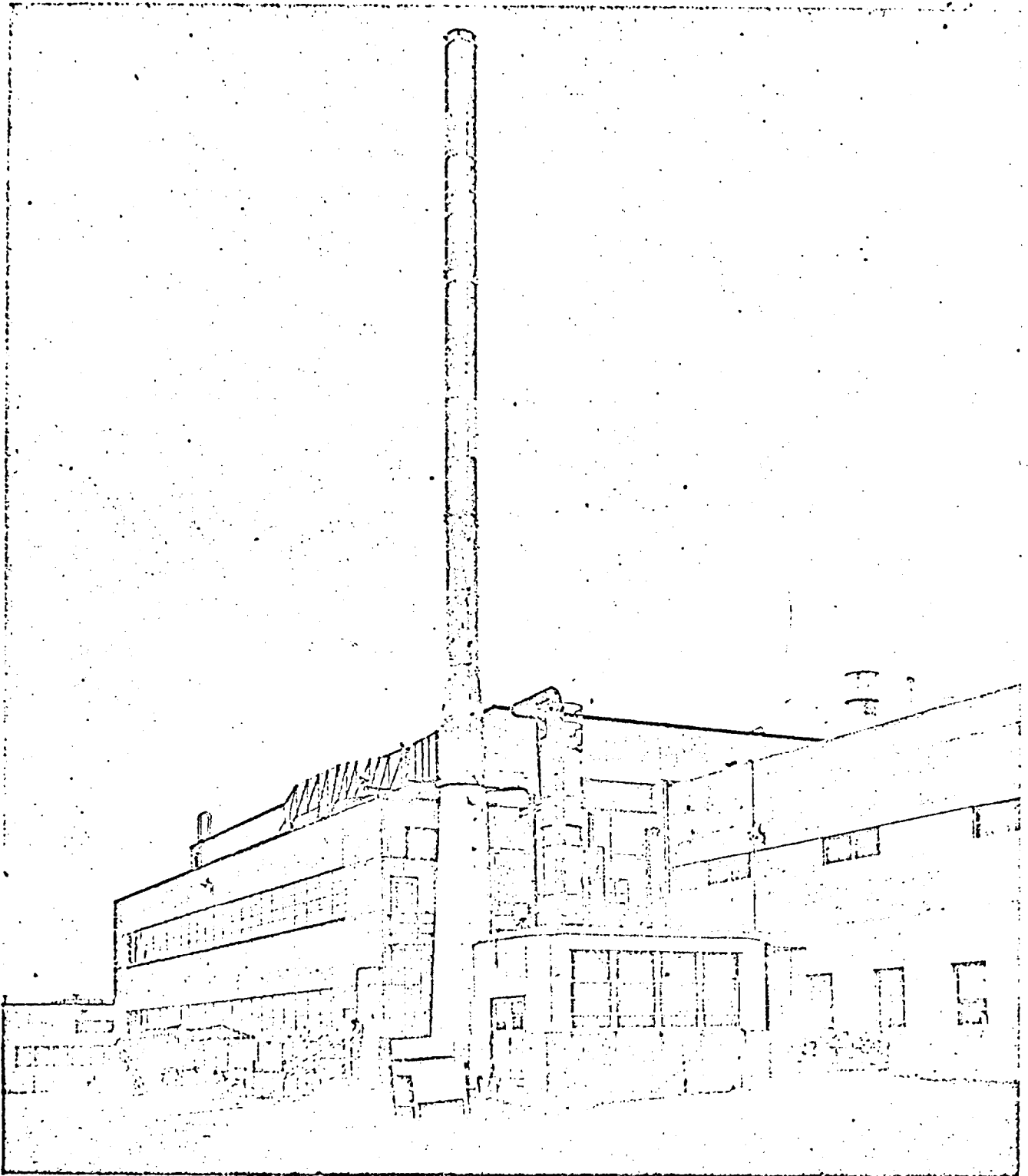
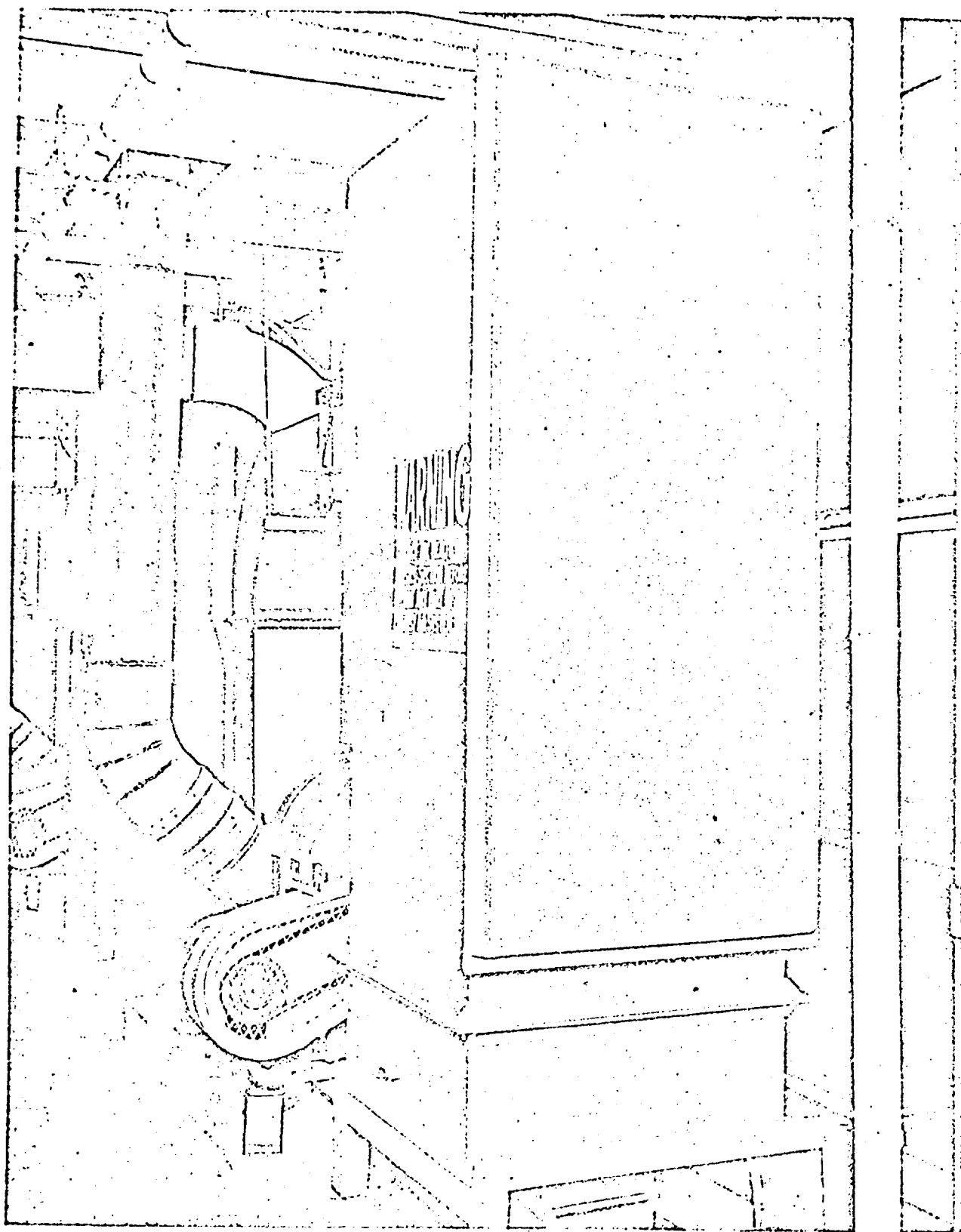


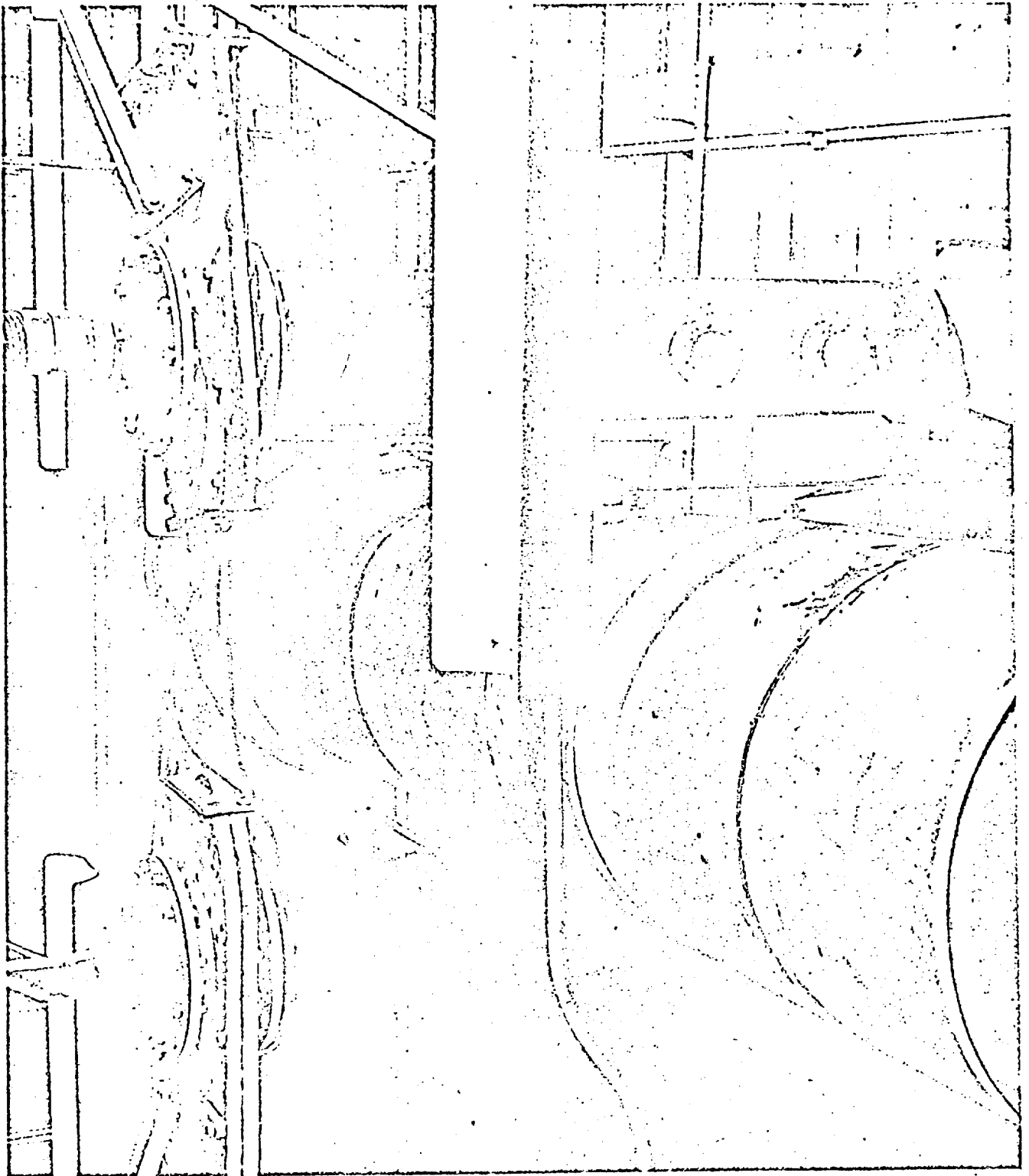
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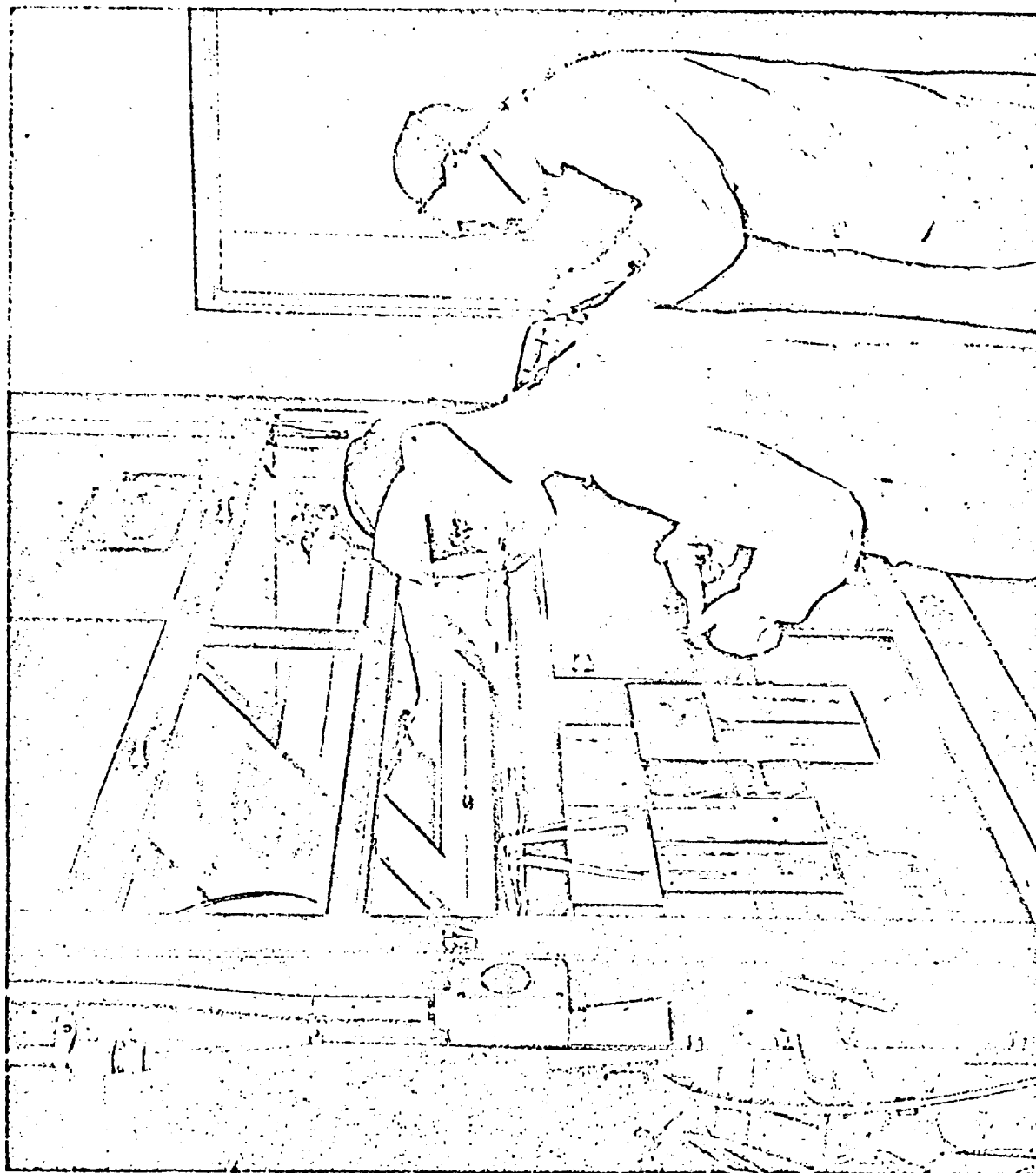
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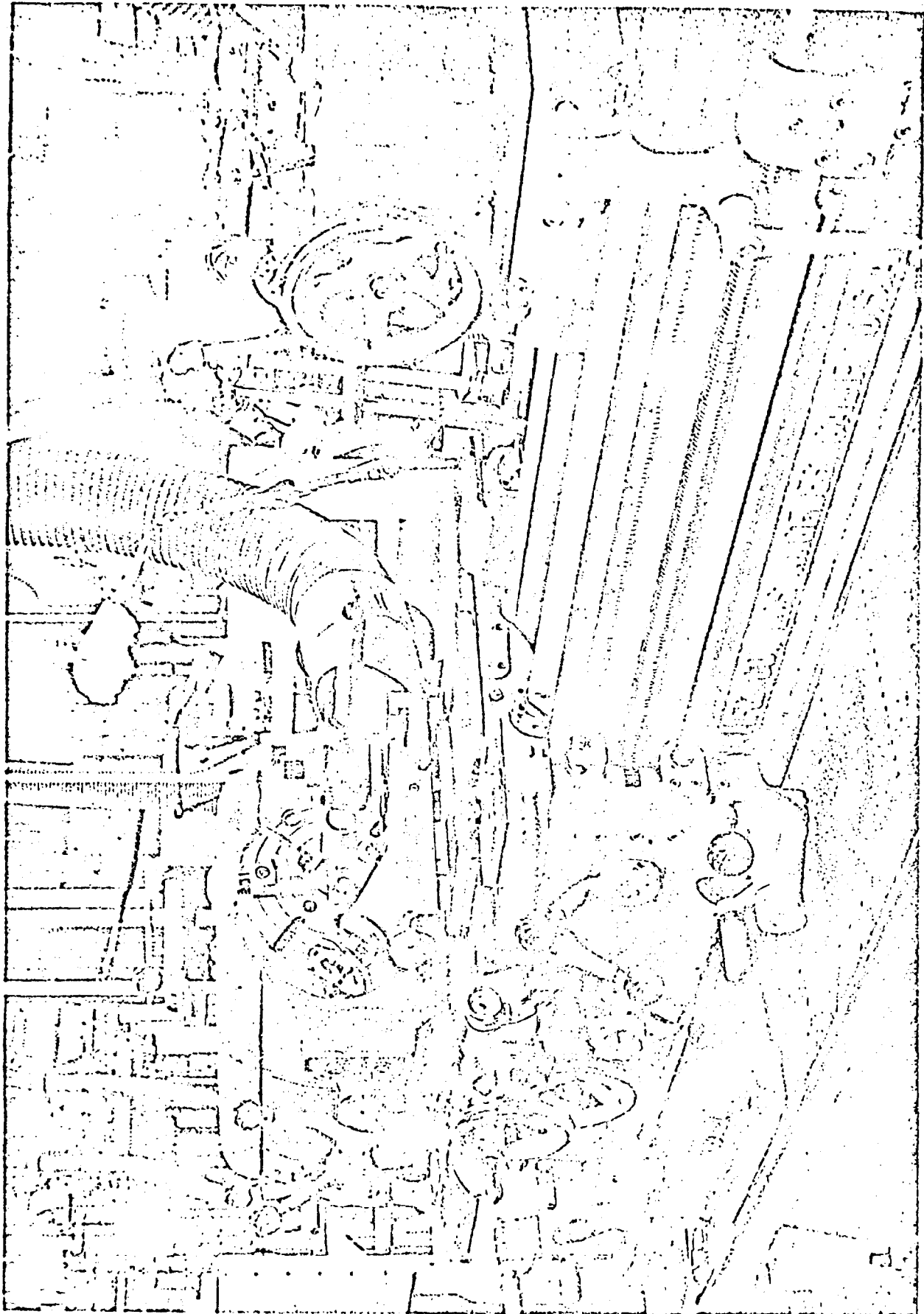
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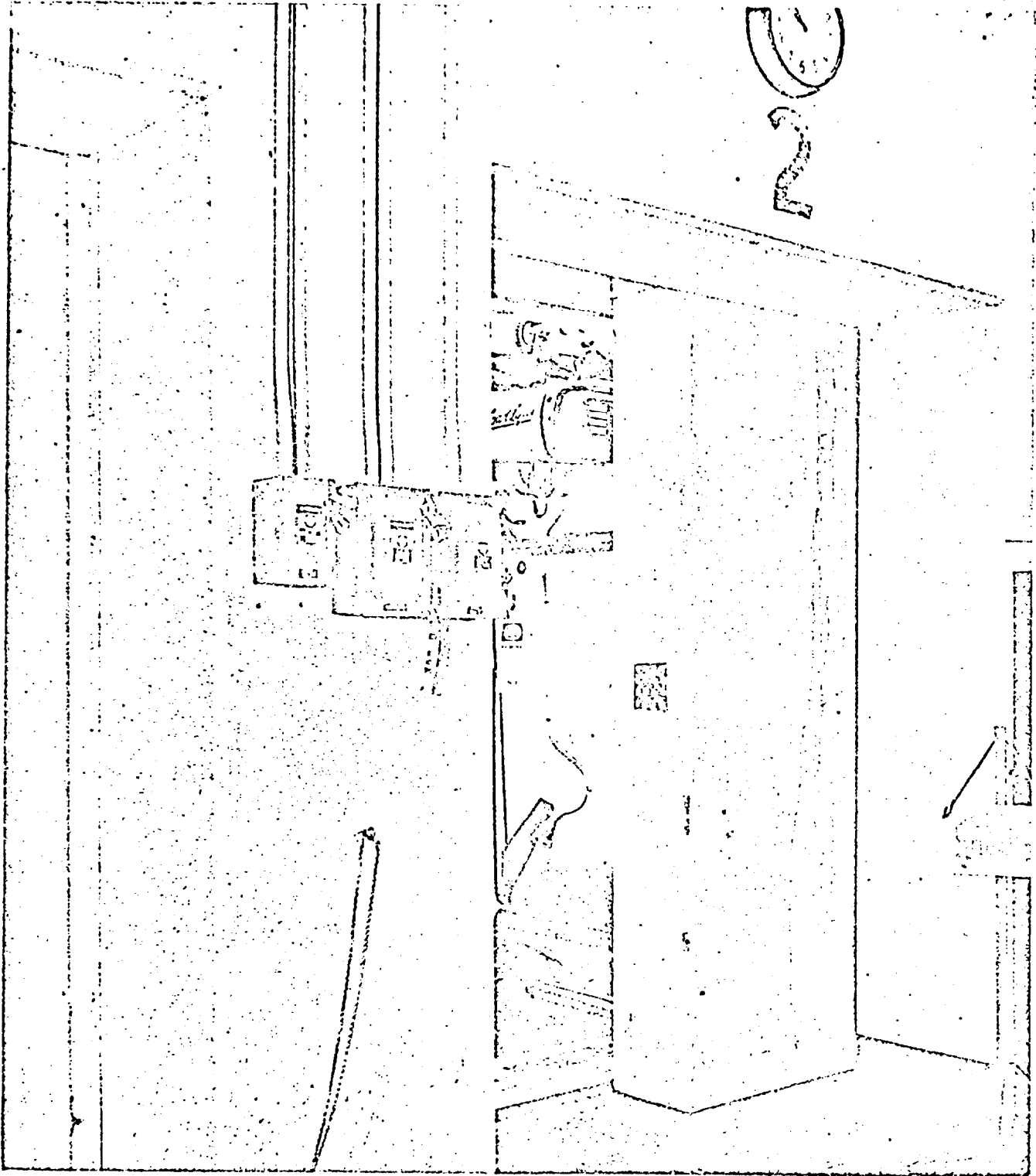
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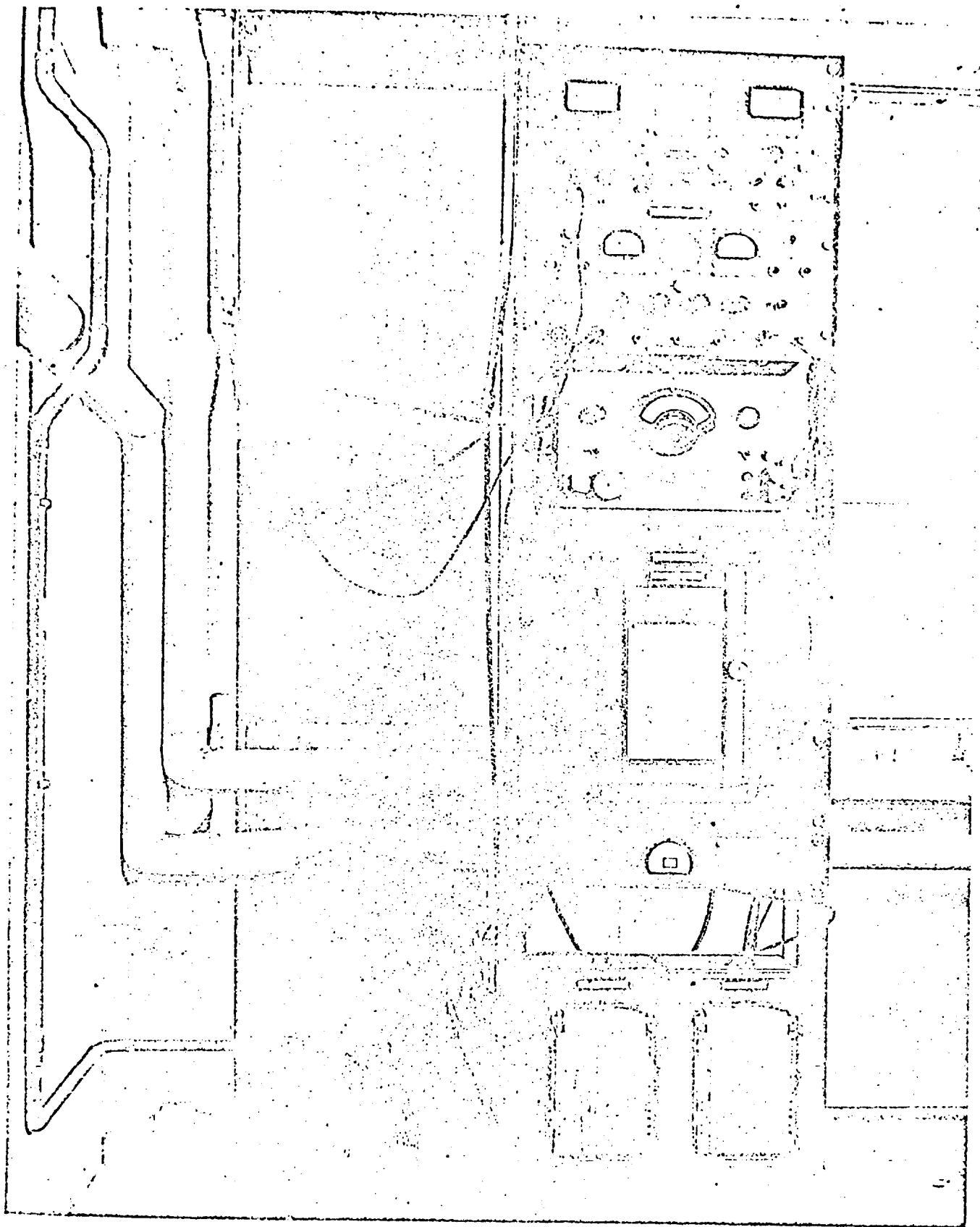
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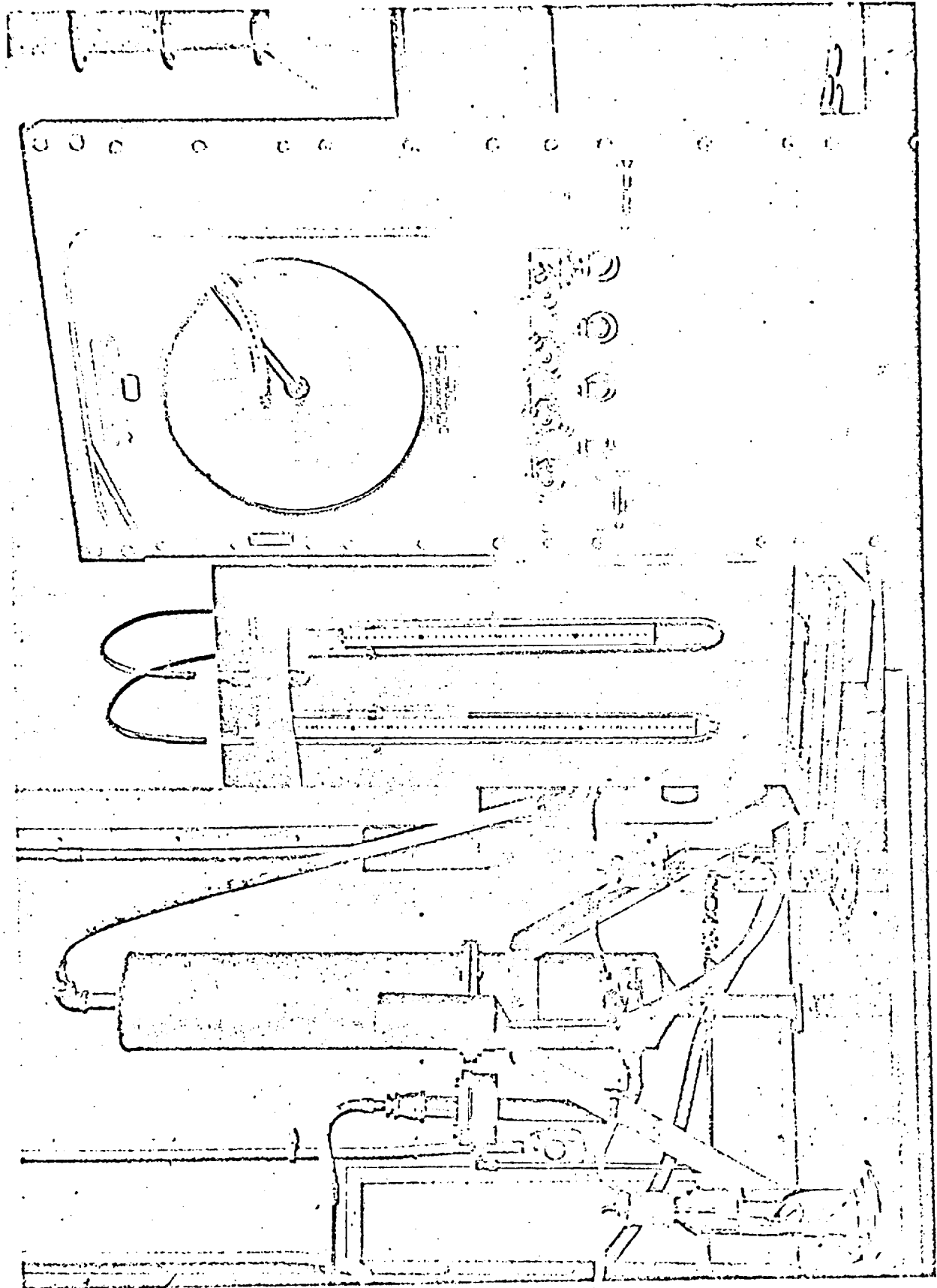
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